

CHAPTER X.

AUXILIARY POWER UNITS FOR REDUCING IDLING EMISSIONS FROM HEAVY-DUTY VEHICLES

This chapter presents the project criteria for auxiliary power units (APUs) that are installed in an on-road heavy-duty vehicle to reduce the vehicle's idling emissions under the Carl Moyer Program. It also contains a brief overview of the engine idling practice of operators of heavy-duty vehicles, NO_x emission inventory, available control technology, potential projects eligible for funding, and emission reduction and cost-effectiveness calculation methodologies.

A. Introduction

Heavy-duty vehicles are often employed in line-haul service carrying goods across the state and throughout the nation. The majority of all heavy-duty vehicles are powered by diesel engines. Heavy-duty vehicles employed in line-haul service are typically greater than 33,000 pounds GVWR and are grouped under a “class 8” truck classification. These vehicles often accrue very high annual mileage. It is not uncommon for a line-haul truck to accrue 100,000 miles, or more, annually. At the same time, however, the engines in these vehicles also operate at idle conditions for a significant amount of time annually, unnecessarily consuming fuel and increasing emissions.

Truck idling practices vary among different fleets, operators, and geographical locations. There are various reasons why line-haul truck operators idle their engines. Two main reasons are to keep the engine and fuel warm, especially in very cold weather, and to heat or cool the cab/sleeper compartment. Since heavy-duty diesel engines do not operate at optimum efficiency at idle conditions, extended engine idling results in increased emissions and fuel consumption. Although technologies for reducing idling emissions from heavy-duty trucks are commercially available, relatively high initial costs have prevented these idling reduction strategies from being more widely utilized.

The Carl Moyer Program can provide incentives to reduce emissions from truck idling by encouraging the purchase and installation of alternative idling reduction technologies. These technologies can not only reduce idling emissions from heavy-duty trucks, but can also result in fuel savings and reduced maintenance costs to truck operators.

1. Emission Inventory

According to EMFAC2000, idling emissions from heavy-duty diesel trucks account for about 21 tpd of NO_x, or about three percent of the total NO_x emissions from this sector of vehicles in California. This inventory may underestimate the actual amount of emissions attributable to truck idling since it only accounts for certain defined events of idling that do not comprise the entire envelope of actual idling practices. Idling emissions from individual trucks are still significant, however, since the idling emission rate for heavy-duty diesel trucks is quite large. For example, a single heavy-duty truck that idles an average of about four hours per day would emit about one-half ton of NO_x emissions annually, just from idling.

2. Emission Standards

Aside from the overall emission standards applicable to heavy-duty diesel engines, there are no specific emissions standards to control heavy-duty engine idling operation. Some local government and municipalities, however, are beginning to consider ordinances restricting the length of engine idling. Since there is no existing emission standards to serve as baseline emission level for the purpose of calculating emission benefits of an idling reduction technology, the EMFAC2000 idling emission rate for heavy-duty diesel trucks shall be used as the idling emission baseline. Currently, some commercially available technology for reducing truck idling emissions make use of a small off-road engine as the power unit for supplying heating and cooling needs to the truck/cab and, in some cases, electricity to power the truck accessory loads. In these cases, the new emission level would be based on the emission standards that these small off-road engines are certified to. Table X-1 lists the existing and future emission standards for small off-road diesel engines that are likely to be employed in APU idling reduction devices.

Table X-1 Emission Standards for 2000 -2004 Model Year Off-Road Compression Ignition Engines 0 – 19 kW (0 - 25.5 hp)		
Pollutants	Power Rating < 8 kW (10.7 hp)	Power Rating 8 < kW<19 (10.7<hp<25.5)
HC + NO _x	10.5 g/kW-hr (7.8 g/bhp-hr)	9.5 g/kW-hr (7.1 g/bhp-hr)
PM	1.0 g/kW-hr (0.75 g/bhp-hr)	0.8 g/kW-hr (0.6 g/bhp-hr)

3. Control Technologies

Several technologies are commercially available that could be employed to reduce idling emissions from heavy-duty trucks. These technologies are discussed below.

a. Auxiliary Power Units

Auxiliary power units (APUs) are self-contained power generating devices, typically packaged with a small internal combustion engine, of 20 horsepower or less, that could be coupled with a generator and heat exchanger to generate electricity and heat. APUs are usually installed on the truck chassis outside the truck cab to provide power for the truck's accessory loads and to keep the engine warm when the truck is parked. This would allow the truck operator to refrain from idling the truck main engine for a significant portion of time. The extent of labor involved in the installation of an APU on the truck is dependent on the configuration of the truck's engine and chassis and the plumbing of its heating/cooling system. Heating and cooling of the cab compartment are accomplished through either dedicated equipment supplied with the APU or through the truck's existing heating and cooling system. APUs are commercially available and would be able to meet most of the power needs of truck operators.

b. Direct-Fired Heaters

Direct-fired heaters for truck heating applications are devices that use the combustion heat of a small internal combustion engine to provide heat directly to the truck's cab/sleeper area through the use of a small heat exchanger. Because it is designed to provide heat directly from a combustion flame, the heating efficiency of these units is much higher than that obtained through the truck's engine due to reduced mechanical losses and fuel consumption. Two primary limitations of direct-fired heaters for this application are that they cannot provide cooling and that they draw on the truck's battery power during operation. Technologies for overcoming the latter limitation are evolving, but this technology has not gained widespread commercial acceptance.

c. Thermal Storage/Direct-Fired Heaters

Another technology that could provide both heating and cooling for the cab/sleeper areas is a thermal storage system. This technology uses the heat of transformation associated with material phase change to provide heating and cooling, respectively, to the cab/sleeper area. This technology currently has several drawbacks: (1) it cannot provide heat to the engine to keep it warm unless a direct-fired heater is also incorporated with the thermal storage system; (2) it cannot provide cooling needs at night unless the truck's air conditioner was used in the daytime; and (3) it uses the truck's battery power.

d. Truck Stop Electrification

Another strategy for reducing truck idling is electrification of truck stops or truck rest areas where trucks are parked overnight. This strategy requires the installation of charging infrastructure at truck stops and rest areas and requires the retrofit of trucks with various components, such as engine block heater, fuel heater, electric heater for cab/sleeper areas, etc. Enabling technologies for an electrification strategy are commercially available.

B. Project Criteria

The project criteria for eligible idling reduction strategies for heavy-duty vehicles provide districts and fleet operators with the minimum qualifications that must be met for a project to qualify for funding. The criteria are developed specifically for APUs that will be installed on a heavy-duty truck to reduce the truck's idling emissions. Idling reduction strategies other than through the use of an APU could be evaluated on a case-by-case basis. Criteria for other idling reduction strategies may be developed in the future depending on the market demand and availability for those specific technologies.

APUs would provide a cost-effective means to reduce idling emissions from heavy-duty diesel trucks. However, because of the attractive life-cycle cost of this technology, Moyer funds should not be used to pay for the full cost of an APU. APUs are expected to pay for themselves in a few years, after which these units will provide a positive revenue stream to the truck owners/operators in the form of fuel savings. The payback period and the amount of fuel savings would depend on the total cost of the units, actual idling hours, fuel prices, and maintenance costs. Therefore, a maximum amount of \$1,500 per diesel APU, and \$3,000 per alternative fuel, electric motor, is allowed in this project category. This amount is intended to help pay for the installation cost of the APU. The amount that would be funded for any individual project would depend on the actual installation cost, but in no case could exceed \$1,500 for a diesel APU and \$3,000 for an alternative fuel or fuel cell APU.

The main criteria for selecting a project are the amount of emission reductions, cost-effectiveness, and ability for the project to be completed within the timeframe of the program. These criteria also provide districts and vehicle operators with calculations that must be used for determining emission reductions and cost effectiveness resulting from idling emission reduction projects.

- Eligible projects must provide at least 15 percent NO_x emission benefit compared to baseline idling NO_x emissions;
- NO_x reductions obtained through this program must not be required by any existing regulations, memoranda of agreement/understanding, or other legally binding documents;
- Engines used in the auxiliary power units must meet current emission standards must be certified by the ARB for sale in California, and must comply with applicable durability and warranty requirements;
- An hour-meter must be installed with the APU to record the actual operating time of the APU and to provide information on the number of hours the APU is utilized;
- The default load factor for the engine used in an auxiliary power unit will be the maximum power rating of the engine, unless other more appropriate load factors are proposed and supported by proper documentation;
- Funded projects must operate for a minimum of 5 years and emission benefits would be based on the vehicle's idling time that occurs in California;

- The actual installation cost of the APU including installation of an hour meter, or up to a maximum of \$1,500 per diesel APU installation, and a maximum of \$3,000 per alternative fuel, electric motor, or fuel cell APU installation may be funded, whichever is less; and
- Projects must meet a cost-effectiveness criterion of \$13,000 per ton of NO_x reduced.

C. Sample Application

In order to qualify for incentive funds, districts make applications available and solicit proposals for reduced-emission projects from heavy-duty vehicle operators. A sample application form is included in Appendix C. The applicant must provide at least the following information, as listed in Table X-2.

D. Emission Reduction and Cost Effectiveness

1. Emission Reduction Calculation.

The emission reduction benefit represents the difference in the emission level of a baseline idling emission level and the emission level of the auxiliary power unit. The emission level is calculated by multiplying an emission factor by an activity level, and, for the auxiliary power unit, by a load factor. Since emission standards for small off-road compression ignition engines are stated in terms of NO_x plus HC, the total "NO_x" emissions emitted from an engine used in an APU are determined using the applicable combined NO_x+HC emission standards.

The NO_x idling emission factors have been included in the recently adopted EMFAC2000 emissions model, which accounts for the settlement agreement between ARB and the diesel engine manufacturers (regarding excess NO_x emissions from the use of alternative injection timing strategies). EMFAC2000 emission factors for truck idling are in units of g/hour. Idling NO_x emission factors for heavy heavy-duty diesel trucks are shown in Table X-3.

2. Cost-Effectiveness Calculations

For auxiliary power unit projects, only the actual installation cost of an eligible new auxiliary power unit, will be funded through the Carl Moyer Program. The maximum installation cost, funded through the Carl Moyer Program, shall not exceed \$1,500 for diesel powered APUs, and \$3,000 for alternative fuel APUs. In order for a project to be considered eligible, the project must meet the \$13,000 per ton cost-effectiveness criterion. The total installed cost of the auxiliary power unit is to be used in cost-effectiveness calculations. That amount is to be amortized over the expected project life (at least five years) and with a discount rate of five percent. The amortization formula (given below) yields a capital recovery factor, which, when multiplied by the initial capital cost, gives the annual cost of a project over its expected lifetime.

Table X-2
Minimum Application Information
Auxiliary Power Unit Projects

1. Air District 2. Project Funding Source: 3. Applicant Demographics Company Name: Business Type: Mailing Address: Location Address: Contact Number: 4. Project Description Project Name: Project Type: Vehicle Function: Vehicle Class: GVWR(lbs): 5. NOx Reduction Incremental Cost Effectiveness Analysis Basis: (Mileage/Fuel/Hours of Operation) 6. VIN or Serial Number: 7. Application: (Repower, Retrofit , Idling, or New) 8. Percent Operated in California: 9. APU Engine Information Horsepower Rating: Engine Make: Engine Model: Engine Year: Fuel Type:	10. NOx Emissions Reductions Baseline NOx Emissions Level (g/hr): APU NOx+HC Emissions Standard (g/kW-hr): Estimated Annual NOx Emissions Reductions: Estimated Lifetime NOx Emissions Reductions: 11. Cost (\$) of Certified APU: 12. Installation cost (\$) of APU: 13. Annual Diesel Gallons Used: 14. Annual Hours Idled (Must be documented or justified): 15. APU Load Factor (Must be documented or use default value): 16. Project Life (years): 17. Existing Truck Engine Information Truck Horsepower Rating: Truck Engine Make: Truck Engine Model: Truck Engine Year: 18. District Incentive Grant Amount Requested: 19. Project Contact:
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Table X-3
NOx Idling Emission Factors for Heavy Heavy-Duty Diesel Trucks
33,000 + lbs GVWR

Weight Class	Grams per Hour
Heavy Heavy-Duty Diesel Trucks	396

$$\text{Capital Recovery Factor (CRF)} = [(1 + i)^n (i)] / [(1 + i)^n - 1]$$

Where,

i = discount rate (5 percent)
 n = project life (at least five years)

The discount rate of five percent reflects the opportunity cost of public funds for the Carl Moyer Program. This is the level of earning that could be reasonably expected by investing state funds in various financial instruments, such as U.S. Treasury securities. Cost-effectiveness is determined by dividing the annualized cost by the annual NOx emission reductions. An example calculation for heavy-duty truck idling reduction project through installation of an auxiliary power unit is provided below.

3. Example

Example 1 – APU Project (Calculations based on Fuel Consumption and Idling Hours). A truck operator proposes to purchase an auxiliary power unit, powered by a certified 8 kilowatt (10.7 horsepower) engine, to be installed on a heavy-duty truck to reduce its engine idling hours. This vehicle idles 100 hours per year in California. The load factor for the APU is documented to be 90% of rated power and the APU would substitute for up to 80% of the truck's idling time. The installation cost of the APU on the truck is \$1,400.

Emission Reduction Calculation

Baseline Truck NOx Idling Emission Factor:	396 g/hr
APU NOx+HC Emission Standard:	10.5 g/kW-hr
Annual Idling Hours in California:	100 hours
Load Factor:	90%
APU Idling Substitution Rate:	80%
Convert grams to tons:	ton/907,200g

The estimated reductions are:

Since 80% of idling load is attributable to the APU, 20% of actual idling load is still carried out by the truck engine, the hourly NOx emission reduction is:

$$396 \text{ g/hr} - ((0.20)(396 \text{ g/hr}) + (0.80)(10.5 \text{ g/kW-hr})(8\text{kW})(0.90)) = 256.3 \text{ g/hr}$$

Annual emission reduction is:

$$256.3 \text{ g/hr} * 100 \text{ hours/year} * \text{ton}/907,200 \text{ g} = \mathbf{0.03 \text{ tons/year NOx emissions}}$$

Cost and Cost-Effectiveness Calculations

The annualized cost is based on the installation cost of the auxiliary power unit, the expected life of the project (5 years), and the interest rate (5 percent) used to amortize the project cost over the project life. The maximum amount that could be funded through the Carl Moyer Program fund is determined as follows:

APU Capital Cost	= \$6,000
APU Installation Cost	= \$1,400
Moyer Amount Requested	= \$1,400
Capital Recovery	= $[(1 + 0.05)^5 (0.05)] / [(1 + 0.05)^5 - 1] = 0.23$
Annualized Cost	= $(0.23)(\$1,400) = \$322/\text{yr}$
Cost-Effectiveness	= $(\$322/\text{year}) / (0.03 \text{ tons/year}) = \mathbf{\$10,733/\text{ton}}$

The cost effectiveness for the example is less than \$13,000 per ton of NO_x reduced. This project would qualify for the maximum amount of grant funds requested, which, in this case, is the entire installation cost.

E. Reporting and Monitoring.

The district has the authority to conduct periodic checks or solicit operating records from the applicant that has received Carl Moyer funds for heavy-duty vehicle idling emission reduction projects. This is to ensure that the auxiliary power unit is operated as stated in the program application. Fleet operators participating in the Carl Moyer Program are required to keep appropriate records during the life of the funded project. Records must contain, at a minimum, total California hours idled. Records must be retained and updated throughout the project life and made available at the request of the district.